Optimized Method Of Estimation Of Critical Flicker Frequency (CFF)

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The threshold frequency for perception of a flickering light (CFF) is an indicator of arousal of the cerebral cortex, and widely used both for clinical and research purposes [1]. The measurement is often based on the method of limits (MOL), presenting a flickering stimulus of steadily increasing or decreasing frequency. This method is not free from biases [2]. The method of constant stimuli (MCS) is more precise but may take more time, so the state of the subject cannot be considered as invariable [2]. We describe a time-saving, computer-controlled method based on MCS modified with feedback from previous responses.

METHOD/RESULTS

The main purpose of the measurement is obtaining the curve similar to that depicted in fig.1 or its derivative. The advantage of our MCS method consists in the adjustment of the interval of frequencies representing [f_{min}; f_{max}] as close as possible to the interval of real changes [f_L; f_H]. Light stimuli of random frequency were presented within a range bracketing the estimated CFF, and the subject pressed a button if the stimulus was perceived as flickering. Testing was continued until at least 10 stimuli (in practice, often many more) had been presented at each 1 Hz interval. Two values were compared as estimates of CFF: the frequency of an extremum of first derivative of this sigmoidal response curve (Fpeak) and mean value of the interval [f_L; f_H] (Fmean). 35 normal subjects have been tested using our method. Initial verification of the method is based on comparison with results obtained by MOL in a subset of 15 subjects on two different days. A device measuring CFF by MOL (Lafayette Instr. Co., Indiana) was modified to be computer driven via the counter-timer board. Special software has been developed by one of us (VF).

Stimuli were presented within a mean range of 6 Hz within which CFF was estimated. Fpeak and Fmean were highly correlated ($r=0.98$; $p<.0001$) and differed by only 0.20 ± 1.66 Hz (mean + std.dev.). Therefore we selected Fpeak as our estimate of the critical flicker frequency. For the full set of subjects (N=35) CFF estimated by Fpeak was 36.5 ± 4.8 Hz. For these subjects, CFF measured on 2 different days was not significantly different. Comparing Fpeak computed by our method to CFF measured by MOL (measured on 15 subjects), the two estimates of CFF differed by less than 0.1 Hz (t= 0.062, ns). Our technique took on average 6.2 min, comparable with the time required for MOL, but provided on average 147 trials for estimation of the probability distribution of CFF versus 20 trials in MOL, affording a two-fold increase in the reliability of CFF estimation.

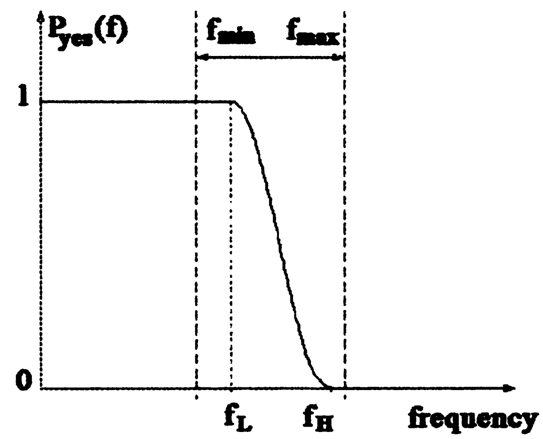

Figure 1. Heuristic dependence of the probability of perception of the light stimulus as "flickering" on the frequency of flicker.

We report a method to estimate CFF which includes desirable features of MCS, but is more rapidly performed. This is possible because we adjust the stimuli presented based on the subject's previous responses. Thus, most data are gathered around the actual estimate of CFF. Our method correlates well with the standard MOL. This method can be further optimized from the viewpoint of statistical precision and minimum time of measurement by reducing the number of stimuli presented to no more than 10 per bin so that measurement will take approximately 3 minutes. A further advantage of this technique is that the data are amenable to analysis by signal detection theory, yielding an estimate of response bias as well as of perceptual threshold.

References

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[2]. B. Aufdembrinke. The Measurement of CFF. Pharmacopsychiatria 1982, 15 (Suppl.1): 5-8.

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